NOTICE

All drawings located at the end of the document.

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LOADING ANALYSIS FOR THE ACTINIDE MIGRATION STUDIES AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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1.0 INTRODUCTION

1.1 Purpose

This report presents actinide loading analysis results for surface water at the Rocky Flats Environmental Technology Site (Site) to support actinide transport modeling for the Actinide Migration Studies (AMS). The AMS mission is to investigate the mobility of plutonium (Pu-239, 240), americium (Am-241), and uranium (U) in the Site environment. The goal of the AMS is to answer the following questions in the order of urgency shown.

1. Urgent: What are the important actinide sources and migration processes that account for recent surface water quality standard exceedances?
2. Near-Term: What will be the impacts of actinide migration on planned remedial actions? To what level do sources need to be cleaned up to protect surface water from exceeding action levels for actinides?
3. Long-Term: How will actinide migration affect surface water quality after Site closure? In other words, will soil action levels be sufficiently protective of surface water over the long-term?
4. Long-Term: Estimate the long-term off-site actinide migration. How will it impact downstream areas (e.g. accumulation)?

These questions will be addressed by mathematical modeling of actinide transport processes designed to predict actinide loads attributed to known sources of actinides in the Site environment. Actinide loading information is needed to calibrate the models, verify modeling results, and evaluate the error of estimation for the models.

The actinide transport models will estimate the quantities of actinides transported to surface water via the environmental pathways listed below:

- Runoff / diffuse overland flow,
- Channeled surface water flow,
- Groundwater transport - both saturated and unsaturated,
- Sub-surface stormwater flow, and
- Airborne transport.

This actinide loading analysis is focused on the channeled surface-water flow transport pathway.

1.2 Scope

Available surface water discharge and actinide activity data from Site monitoring programs were compiled to compute actinide loads on a storm-specific and annual basis. These data might reveal trends indicative of transport phenomena associated with changing hydrologic conditions (e.g. years with normal, higher than normal, or lower than normal precipitation). The loading analysis was done for Site watershed sub-basins, which are coincident with locations of stream gaging and runoff sampling stations.

The results of this analysis will be used to calibrate transport computer models to Site conditions, such as the U. S. Department of Agriculture (USDA) Watershed Erosion Processes Prediction (WEPP) model. Comparison of the loading and yield results contained herein to the WEPP model output will aid in calibration of the model input data.. For example, the WEPP model output includes the quantity of sediment that leaves the outlet of a watershed on an annual basis. This report includes estimates for the annual total suspended solids (TSS) yields measured at Site stream gaging stations, and these estimates will serve as target results for the WEPP model.

The runoff coefficient is a hydrologic parameter for predicting storm runoff using the Rational Method (Dunne and Leopold, 1978). The runoff coefficient describes the percentage of precipitation that will run off of a drainage basin as surface water. Runoff coefficients approach a value of 1.0 for impervious surfaces, such as paved roads and developed areas. Likewise, the runoff coefficients are typically much lower (e.g. 0.05 to 0.7) for natural surfaces. Estimated runoff coefficients will be used to calibrate the hydrologic components of the WEPP model. Runoff coefficients shown herein will be used so that the WEPP model may be predict a reasonable quantity of runoff.

2.0 Study Area

The study area includes the Woman Creek, Walnut Creek, and South Interceptor Ditch (SID) drainage basins, the SID being contained in the Woman Creek watershed (Figure 1). The study area includes the Site property from the west fence line to the east fence line, and extends east to higher order water bodies downstream from the Site. For some monitoring stations, data are limited or do not exist for reliable estimation of actinide loading to off-Site water bodies, but projections can be made based on monitoring done at the eastern-most (downstream) extent of the Site property.

3.0 Description of Data Sources

Data for this analysis were compiled from the following Site monitoring programs:

- Event-Related Surface Water Monitoring Program, 1991-1994;
- Industrial Area IM/IRA Monitoring Program, 1995-Present;
- Rocky Flats Cleanup Agreement (RFCA) Monitoring Program: 1996-Present; and
- Source Evaluation and Preliminary Mitigation Program: 1997-Present.

Automated stormwater monitoring equipment has been used since 1991 to collect stormwater runoff samples from three Site drainages: Rock Creek, Walnut Creek, and Woman Creek. The equipment for this activity consists of a continuously recording flow meter linked to an automatic water sampler, which draws a composite sample from the stream when the flow meter indicates that desired flow conditions exist (e.g. rising stream due to stormwater runoff). The equipment may be programmed to collect samples on either time-paced (e.g. one sample every 15 minutes) or flow-paced (e.g. one sample every 100 cubic feet) intervals. The instrumentation may be programmed in many different ways to collect water samples representing various hydrologic conditions such as: baseflow, runoff, or a combination of the two.

Since 1991, the Site has continually improved its ability to accurately measure stream discharge and stormwater runoff flows, with the most marked increases in accuracy occurring in 1994. Therefore, loading computations for years prior to 1994 should be regarded as estimations with considerable uncertainty. In a similar fashion, the minimum detectable activity (MDA) for actinides was reduced from approximately 0.08 picocuries per liter (pCi/L) to a range of 0.01 - 0.02 pCi/L over the same time frame. These are important qualifications of the data quality and comparability that might limit the usefulness of earlier (i.e. 1991-1993) data. Nonetheless, these data are shown herein for completeness.

Changes in sampling methodology from 1991 to the present also affect the accuracy and applicability of the loading computations. For example, from 1991-1992 sampling was focused on event-related (stormwater) monitoring, and samples were collected over the entire duration of stormwater runoff events. During 1993-1995, stormwater samples were collected on the rising portion of the stormwater runoff hydrograph to capture what is expected to be the poorest water quality during the first flush of the storm events, thereby increasing the possibility of detecting actinides in the surface water.

From 1991 to 1995, baseflow water-quality was virtually ignored because water-quality compliance monitoring results showed actinide activities below the Site-specific discharge standards, and often below the MDA at baseflow.

Initiation of the Rocky Flats Cleanup Agreement (RFCA) in 1996 brought changes to the monitoring program through the Integrated Monitoring Plan. Starting in 1996, the sampling has been done by continuous, flow-paced collection of composite water samples to provide measurement of flow-weighted water quality for all hydrologic conditions (e.g. baseflow as well as stormwater runoff). The continuous flow-paced samples provide the best representation of the annual total yields measured at each gaging station.

The data used for this study are from Site stream gaging stations shown on Figure 1. The data include the parameters listed in Table 1. The required resolution for the data, as determined in the Actinide Migration Study Data Quality Objectives (Kaiser-Hill, 1998) are also shown in Table 1. The data were compiled in Excel™ spreadsheets for computation of the actinide loads.

4.0 Approach

The loading analysis was done to estimate the quantities of water, TSS, Pu-239,240, Am-241, and U that pass through and off of the Site property. The results of the analysis will be used to calibrate the WEPP erosion model to estimate actinide migration from erosion and sediment transport processes.

The data analyzed included continuous stream discharge and water-quality data. Each water-quality sample that was used had a corresponding average flow measured during collection of the sample. As mentioned previously, much of the monitoring data was for storm events, and only about ten percent of the storm events were sampled. These loads presumed to represent the poorest water quality and highest flows that are observed at the Site. Therefore, the computed loads and yields are positively skewed (i.e. biased toward larger than average loads and yields).

4.1 Calculation of Storm-Specific Loads and Annual Yields

Actinide and TSS loads were computed for each gaging station over the period of record with all available data using Equation 1. In order to put the actinide load and yield estimates into a form that is comprehensible, radionuclide activities were converted to mass using activity/mass ratios shown in Table 2 (Shleien, 1992).

Table 1.—Data Needs for Actinide Loading Analysis in Support of AMS Modeling Activities.

Parameter	Required Resolution for Analysis
continuous stream discharge	0.1 cubic feet per second (cfs)
plutonium-239,240 (Pu-239,240);	0.02 pCi/L
americium-241 (Am-241)	0.02 pCi/L
uranium-233,234 (U-233,234)	0.02 pCi/L
uranium-238 (U-238)	0.02 pCi/L
total suspended solids	10 mg/L
drainage areas tributary to each gaging station	0.5 acres
precipitation data	0.05 inch, 15-minute record

Table 2.—Activity to Mass Ratios for Selected Radionuclides for Conversion of Activity Data to Mass for Load and Yield Computation.

Radionuclide	Activity-to-Mass Ratio (Ci/g)
Plutonium-239,240	0.07
Americium-241	3.43
Uranium-233,234	6.2×10^{-3}
Uranium-235	2.2×10^{-6}
Uranium-238	3.4×10^{-7}

Notes: 1) Uranium isotope activity to mass ratios are for natural uranium.
2) Ci/g = Curies per gram.

<u>Equation 1:</u> Load (mass transport / time) = K x Q x [constituent];

where:

Load = a "mass flow," commonly called "flux" in units of mass per unit time (e.g. μg/year);

K = a constant for appropriate unit conversion;

Q = stream discharge, in Liters / second; and

[constituent] = actinide (μg/L) or TSS (mg/L) concentration.

Equation 1 is used to compute storm-specific loads using the average flow that is measured during collection of the stormwater sample. The minimum, mean, and maximum storm-specific loads were calculated for each gaging station.

The estimations of TSS and actinide loads at each gaging station were used to compute annual total yield (i.e. total mass) of TSS and actinides transported to each station (Equation 2). The yields may be compared spatially to locate actinide source and deposition (sink) areas.

Equation 2: $Y = K \times V_w \times [\text{constituent}]_{Ave}$

where:

Y = Constituent Yield (mass) (e.g. μg);

K = Constant for appropriate unit conversion;

V_w = Annual total water yield (Volume), in Liters; and

$[\text{constituent}]_{Ave}$= Average annual actinide (μg/L) or TSS (mg/L) concentration.

Discharge and water-quality data for the May 17, 1995 flood, were included in this analysis for stations SW027, GS21, GS22, GS24, GS25, GS10, and SW093. The loading estimates from the May 17, 1995 event are representative of expected actinide transport during floods. The May 17, 1995 event was approximately a 15-year, 24-hour precipitation event that occurred during saturated soil conditions and produced runoff approximating a 50 to 75 year event (RMRS, 1995). The number of days per year with measurable precipitation are shown in Table 3.

5.0 Results

Summary statistics for actinide and TSS loads and annual total yields for each gaging station are shown in Appendices A-2 through A-8, Appendices B-1 through B-5, and Appendices C-1 through C-3. The level of detail in the analysis for each gaging station depended on the quantity of data available for each station. Annual total constituent yields for each gaging station are shown in Figures 2 through 7.

5.1 Quantification of Uncertainty

The uncertainty in the load and yield estimates may be computed using the uncertainties associated with measuring the actinide activity in the water samples, the TSS concentrations, and stream discharge to provide a range of expected values. An analytical error term is supplied with each radiochemical analysis. The analytical error represents two standard deviations from the expected mean activity for each sample, based on the *Poisson* Distribution. No error of estimate is supplied with the TSS data. Therefore, the error associated with these measurements was estimated by comparing field duplicate sample analysis results to determine a relative percent error of 12% (Appendix 1).

Discharge measurements at the Site are normally made using Parshall flumes, H-flumes, cutthroat flumes, v-notch weirs, and rectangular weirs. It is generally accepted by numerous authors that the error of Parshall flumes is about +/- 5%, and the error for weirs are estimated to be slightly less than Parshall flumes. There also is error in the calibration of the flow meters and in estimating discharge for periods with missing data. These errors cannot be specifically quantified. Therefore, for this study, the error term for all discharge measurements was estimated at +/- 10% to account for the error associated with the theoretical ratings for the primary devices (e.g. Parshall flume) and potential instrumentation errors.

It is assumed that the error terms are additive. Therefore, the overall uncertainties are calculated as follows.

$$\text{Uncertainty of Load or Yield Calculation} = \pm (U_{constituent} + U_Q)$$

where: $U_{constituent}$ = Uncertainty for radiochemical or TSS analysis, and
U_Q = Uncertainty for stream discharge measurement.

Table 3.--Number of Days with Measureable Precipitation
(Measured by Site Precipitation Gages)

Water Year	Days with Measureable Precipitation
1991	109
1992	83
1993	130
1994	127
1995	136
1996	120
Average:	**118**

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Figure 2.--Estimated Annual Total Uranium and Suspended Solids Yields in Woman Creek

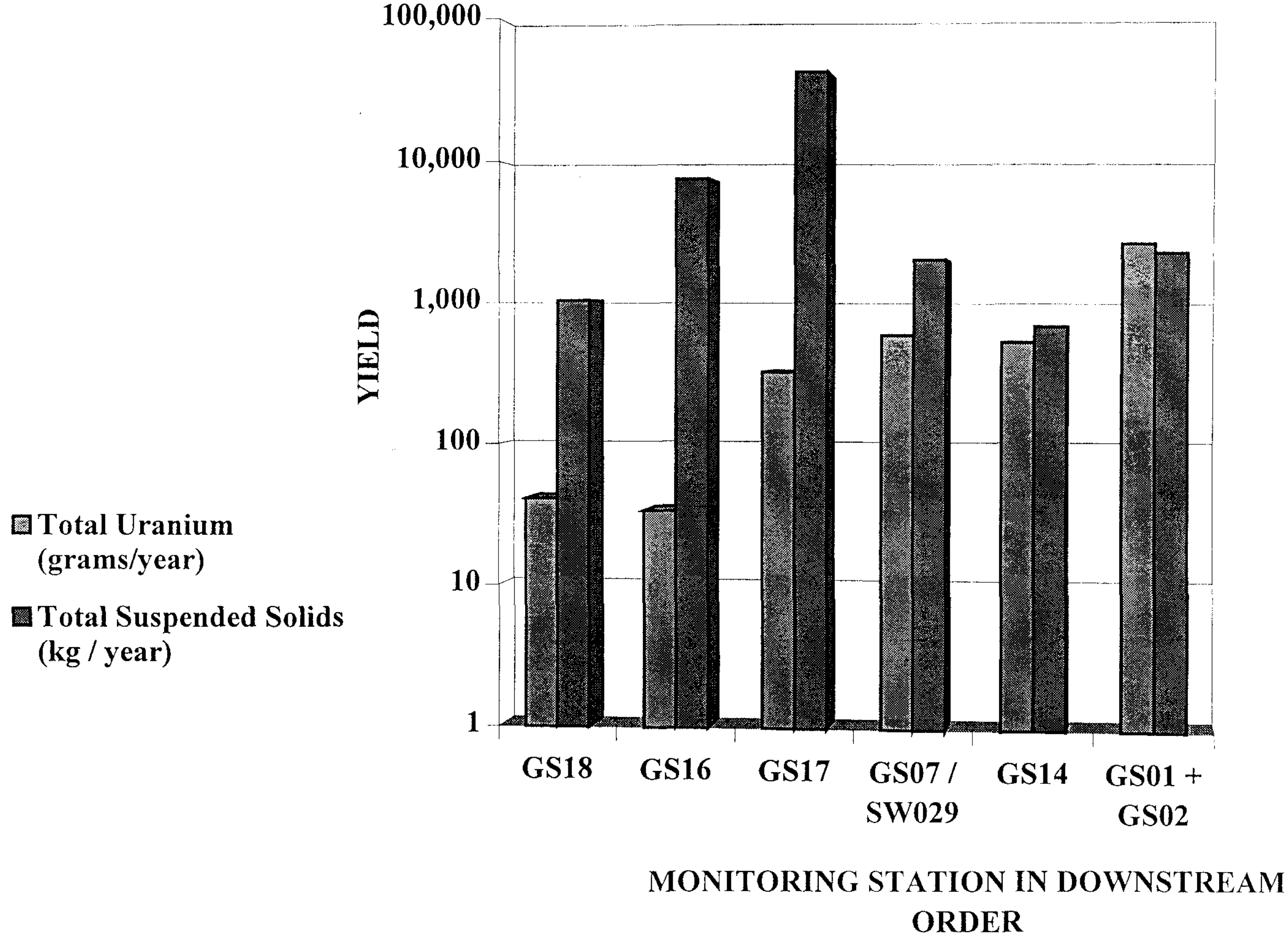


Figure 3.--Estimated Annual Total Plutonium and AmericiumYields in Woman Creek

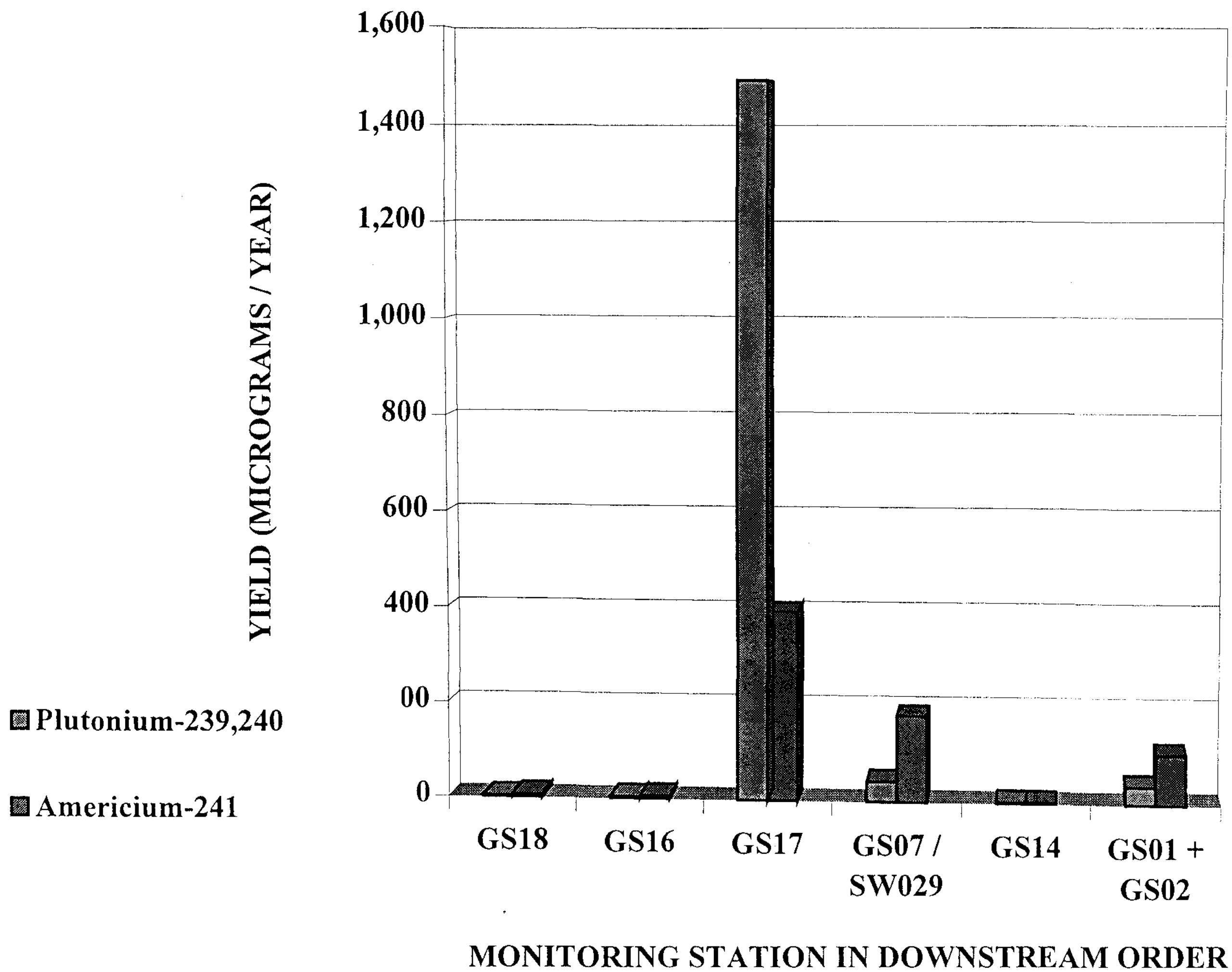


Figure 4.--Estimated Annual Total Plutonium and Americium Yield in South Interceptor Ditch

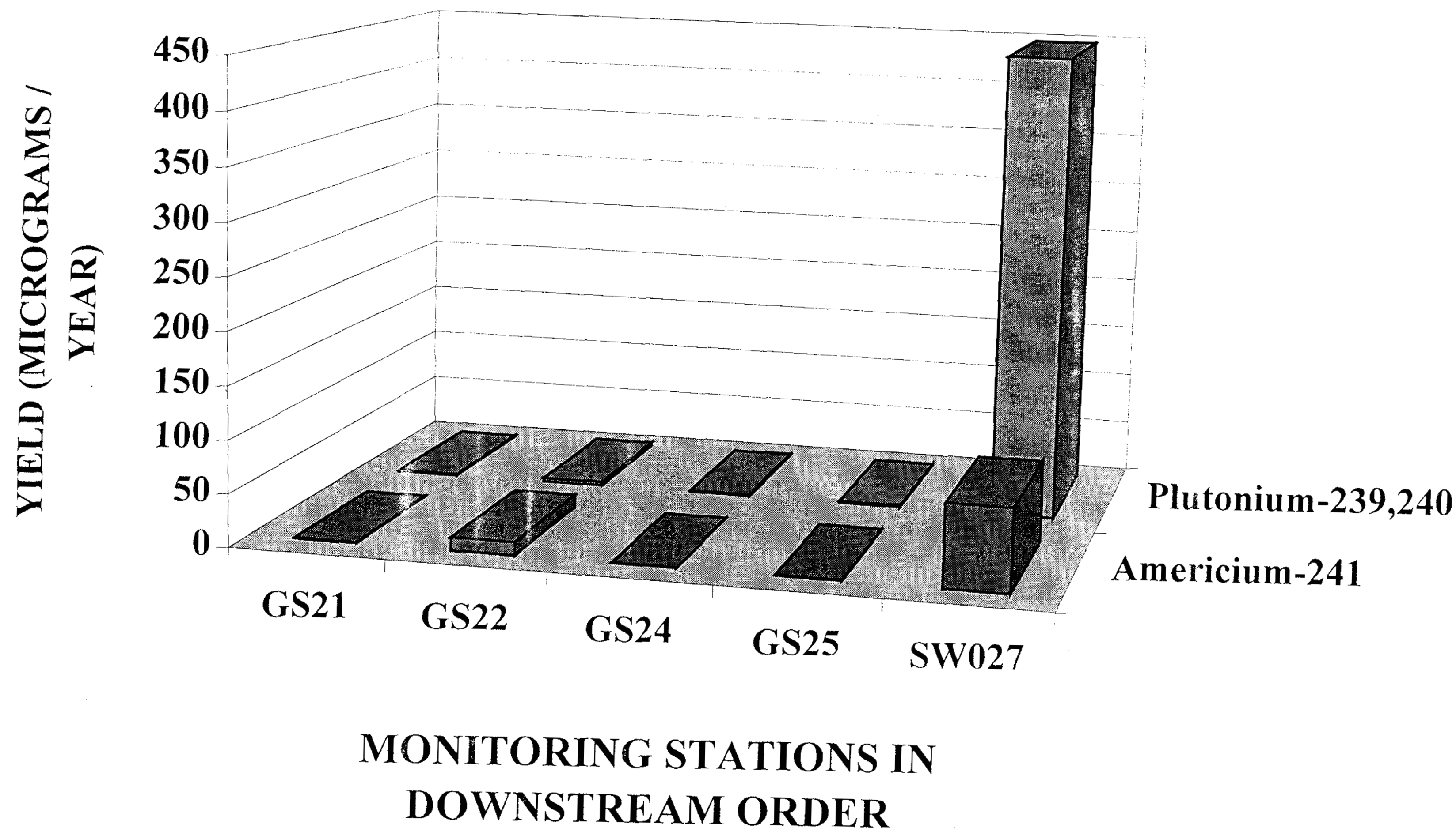


Figure 5.--Estimated Annual Total Uranium and Suspdended Solids Yields in the South Interceptor Ditch

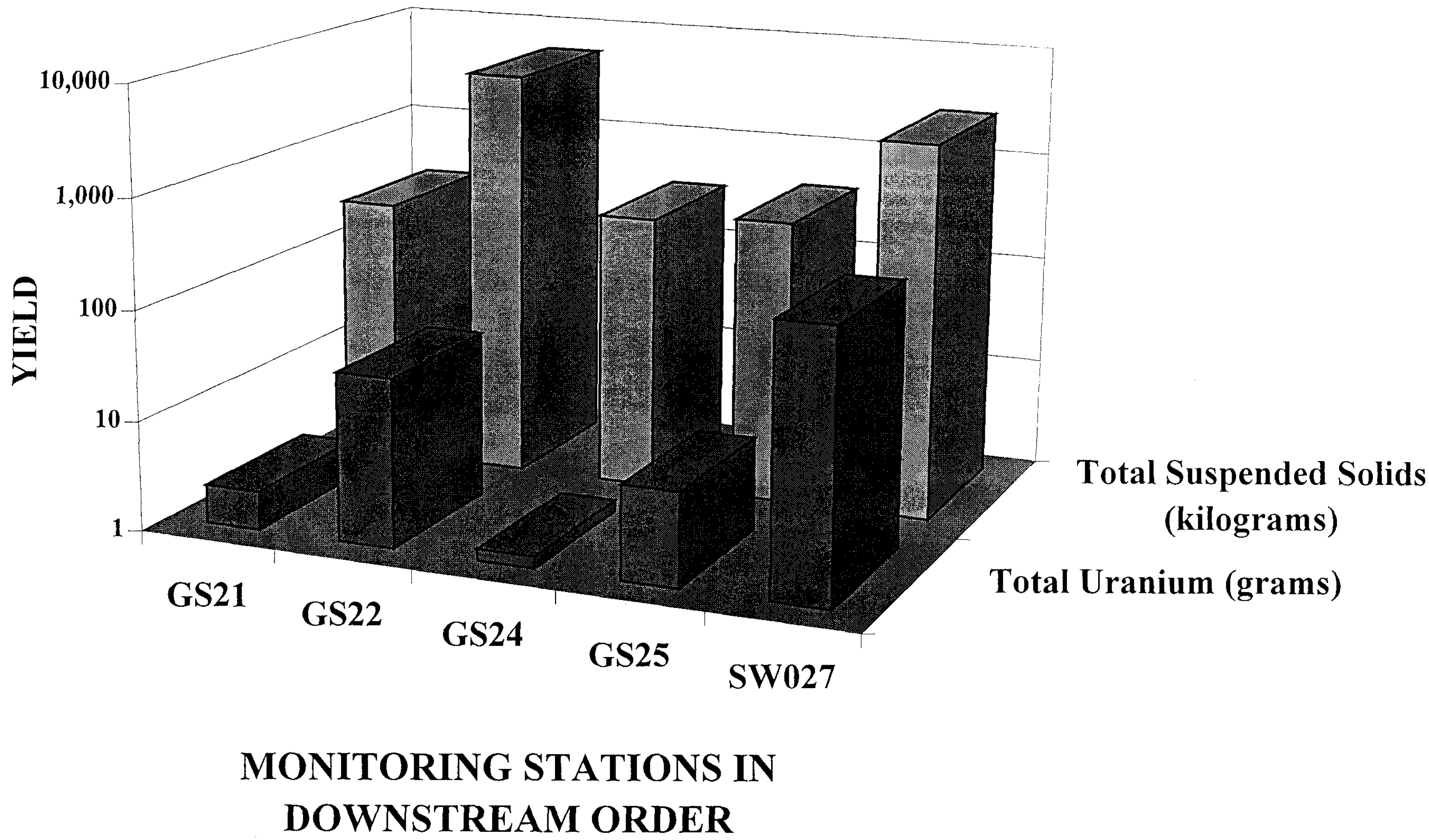


Figure 6.--Estimated Annual Total Uranium and Suspended Solids Yields in Walnut Creek

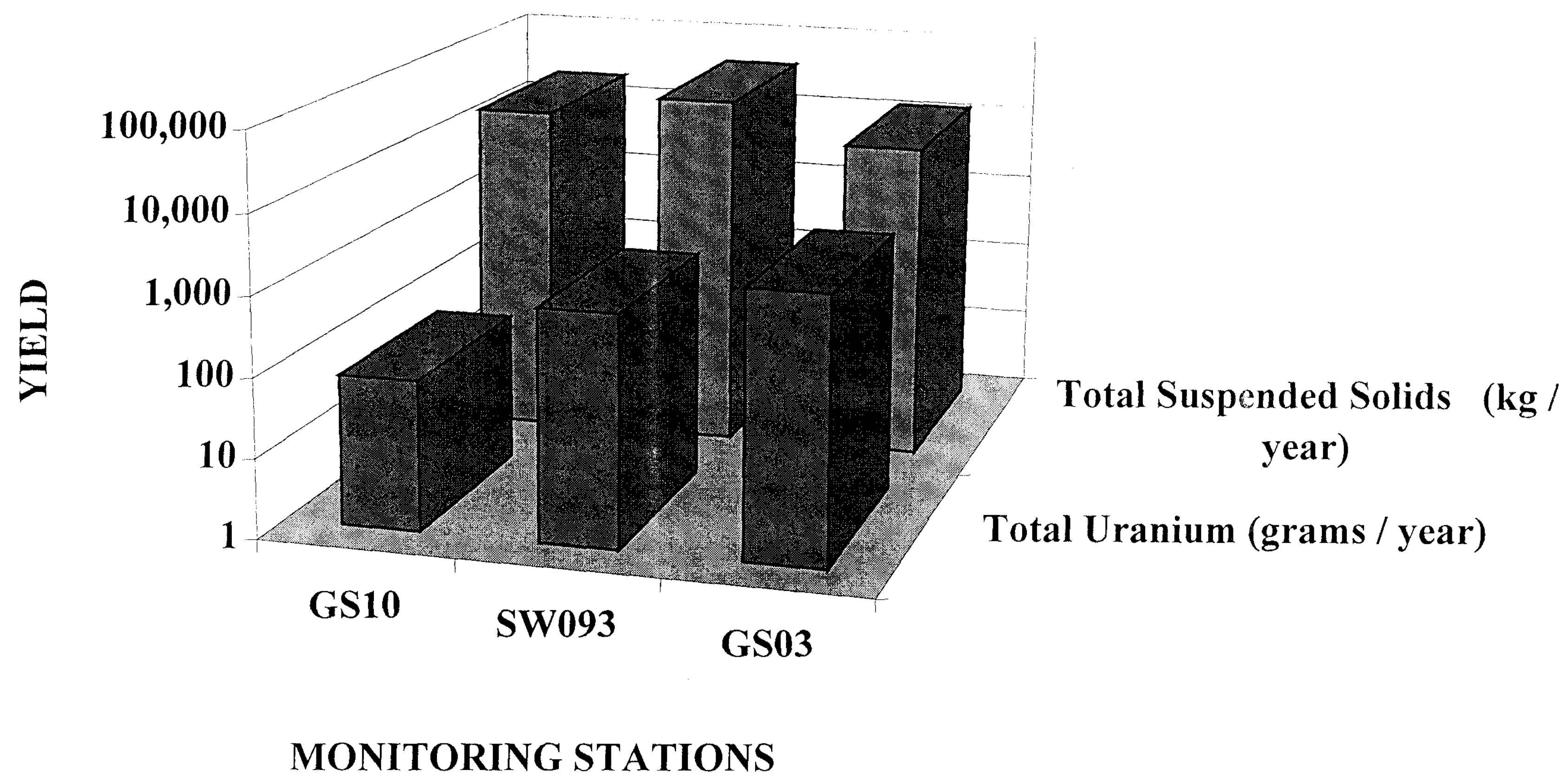
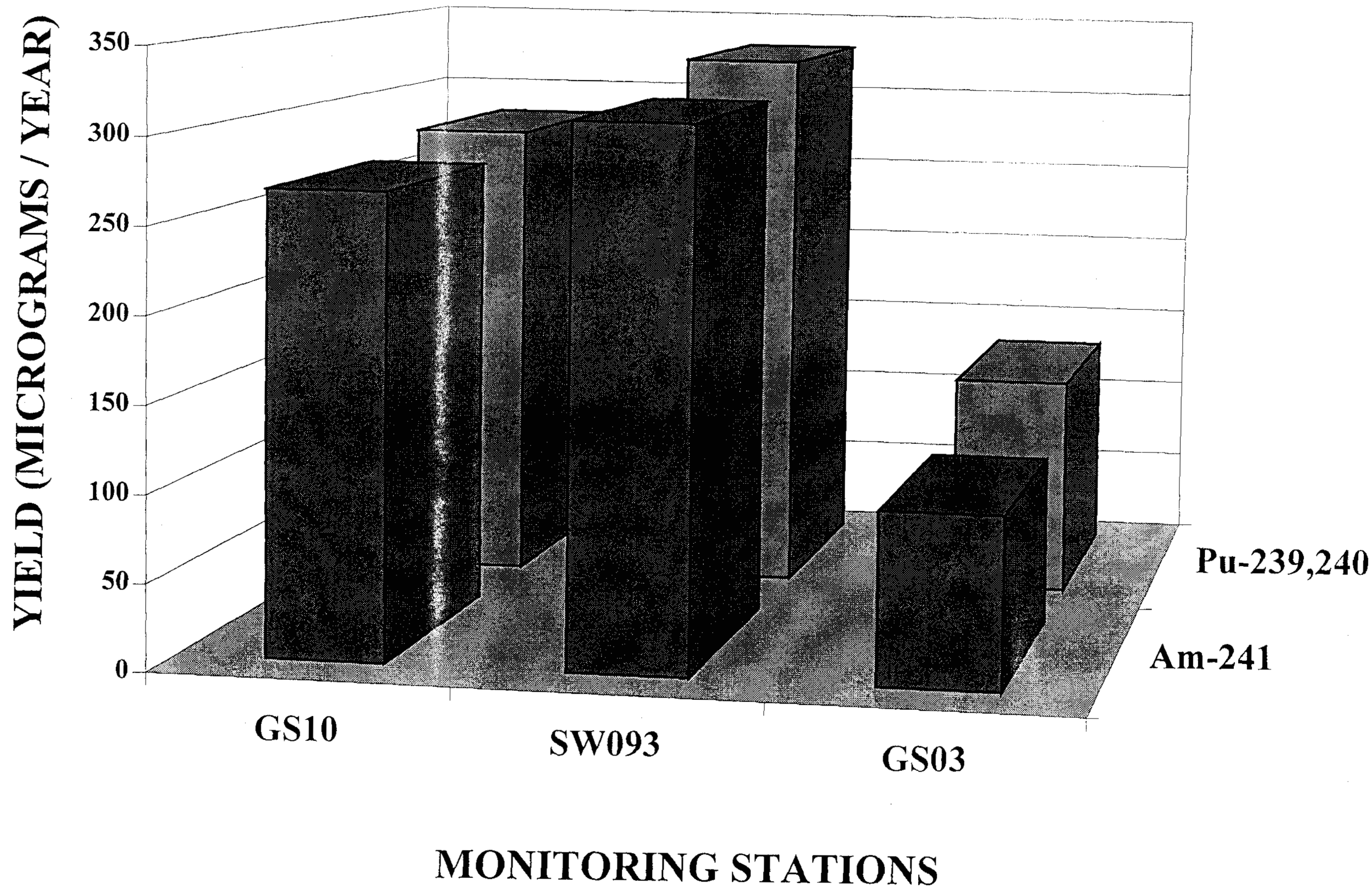


Figure 7.--Estimated Annual Total Plutonium and Americium Constituent Yields in Walnut Creek



The uncertainty data are labeled as error terms in Appendices A2 - A8, B1 - B5, and C1 - C3. The error terms associated with the actinide loads tend to be larger for smaller annual total loads, and vise-versa. This is due to the fact that the uncertainty, in the radionuclide activity measurements tends to decrease with increasing activity.

The same error terms associated with the calculation of storm-specific loads are also applied to the calculation of annual total yields. However, another error inherent in the yield calculation that is not quantified is embodied in the assumption that the constituent concentrations for stormwater runoff events represent average concentrations for all hydrologic conditions. The error associated with this assumption is not quantified. The runoff water is suspected to have greater constituent concentrations than at baseflow. Therefore, the yields presented herein represent maximum expected values.

5.2 Unit Suspended Solids and Actinide Yields

Annual TSS and actinide yields were computed on a unit drainage area basis for calibration and verification of the erosion and actinide transport models. Estimated annual unit yields are shown in Tables 4, 5, and 6 for Woman Creek, the SID drainage, and Walnut Creek respectively. The same drainage sub-basins used to compute the yields per unit acre should also be used for modeling transport processes to facilitate direct comparison of the monitoring results to WEPP erosion model results.

Table 4.-- Summary of Estimated Actinide and TSS Annual Total Yields for Woman Creek.

Based on Data Obtained 1991 - 1997
[Pu = Plutonium-239,240, Am = Americium-241, U = Total Uranium, TSS = Total Suspended Solids, pCi = picocuries, cm = centimeters]

WOMAN CREEK GAGING STATION	CONSTITUENT	ESTIMATED ANNUAL TOTAL YIELD (Pu & Am in µg U in g & TSS in kg)	ESTIMATED ANNUAL TOTAL YIELD / ACRE (Pu & Am in µg / acre, U in g/acre & TSS in kg / acre)	ESTIMATED ANNUAL SOIL EROSION DEPTH IN DRAINAGE BASIN (mm)
GS18	Pu	3	0.01	
Woman Creek	Am	6	0.013	
Below Old Landfill	U	41	0.082	
Drainage Area: 501 Acres	TSS	1,040	2	0.00034
GS16	Pu	5	0.03	
Antelope Springs Gulch	Am	6	0.05	
at Fire Break Road	U	34	0.25	
Drainage Area: 135 Acres	TSS	7,440	55	0.00908
GS17	Pu	1,490	2	
Woman Creek Above	Am	396	0.50	
Pond C-1	U	325	0.41	
Drainage Area: 800 Acres	TSS	41,309	52	0.00851
GS07 / SW029	Pu	43	0.05	
Woman Creek at	Am	181	0.22	
Pond C-1 Outfall	U	593	0.74	
Drainage Area: 806 Acres	TSS	2,020	3	0.00041
GS14	Pu	3	0.003	
Woman Creek above	Am	2	0.002	
Mower Diversion	U	529	0.59	
Drainage Area: 893 Acres	TSS	686	1	0.00013
GS01 + GS02	Pu	38	0.02	
Woman Creek & Mower Ditch	Am	105	0.068	
at Indiana Street	U	2,621	1.70	
Drainage Area: 1545 Acres	TSS	2,265	1	0.00024

Table 5.-- Summary of Estimated Actinide and TSS Annual Total Yields for the South Interceptor Ditch.

Based on the Data Obtained 1991 - 1997

[Pu = Plutonium-239,240, Am = Americium-241, U = Total Uranium, TSS = Total Suspended Solids, pCi = picocuries, cm = centimeters]

SOUTH INTERCEPTOR DITCH GAGING STATION	CONSTITUENT	ESTIMATED TOTAL ANNUAL YIELD (Pu & Am in μg U in g & TSS in kg)	ESTIMATED TOTAL ANNUAL YIELD / ACRE (Pu & Am in μg / acre, U in g/acre & TSS in kg / acre)	ESTIMATED ANNUAL SOIL EROSION DEPTH IN DRAINAGE BASIN (mm)
GS21 IA Runoff from Cactus and 7th Near Bldg. 664 Drainage Area: 2.66 Acres	Pu Am U TSS	1 1 2 271	0.47 0.31 1 102	0.017
GS22 Bldg. 460 Runoff and Footing Drain Discharge to SID *Drainage Area: 14.1 Acres*	Pu Am U TSS	4 12 34 5,657	0.25 1 2 401	0.066
GS24 Bldg. 881 and 850 Runoff to 881 Hillside *Drainage Area: 5.84 Acres*	Pu Am U TSS	1 0 1 333	0.22 0.07 0.22 57	0.009
GS25 East Bldg. 881 and 891 Hillside Runoff with 881 Sump Flows *Drainage Area: 6.7 Acres*	Pu Am U TSS	1 1 7 401	0.18 0.10 1 60	0.010
SW027 South Interceptor Ditch (SID) at Inflow to Pond C-2 *Drainage Area: 186 Acres*	Pu Am U TSS	447 78 250 2,654	2 0.42 1 14	0.002

Table 6.-- Summary of Estimated Actinide and TSS Annual Total Yields for Walnut Creek.

Based on the Data Obtained 1991 - 1997

[Pu = Plutonium-239,240, Am = Americium-241, U = Total Uranium, TSS = Total Suspended Solids, pCi = picocuries, cm = centimeters]

WALNUT CREEK GAGING STATION	CONSTITUENT	ESTIMATED TOTAL ANNUAL YIELD (Pu & Am in μg U in g & TSS in kg)	ESTIMATED TOTAL ANNUAL YIELD / ACRE (Pu & Am in μg / acre, U in g/acre & TSS in kg / acre)	ESTIMATED ANNUAL SOIL EROSION DEPTH IN DRAINAGE BASIN (mm)
GS10 South Walnut Creek Above B-Series Bypass *Drainage Area: 180 Acres*	Pu Am U TSS	281 268 78 20,185	2 1 0.43 112	0.018
SW093 / GS13 North Walnut Creek Above A-Series Bypass *Drainage Area: 249 Acres*	Pu Am U TSS	330 311 784 38,148	1 1 3 153	0.035
GS03 Walnut Creek at Indiana Street *Drainage Area: 987 Acres*	Pu Am U TSS	131 99 2,061 12,264	0.13 0.10 2.1 12.425	0.011

5.3 Estimated Annual Soil Erosion

The expected depth of annual soil erosion was estimated for the Woman Creek, Walnut Creek, and SID drainage basins by dividing the unit TSS yield by an assumed average soil bulk density of 1.5 grams / cubic centimeter (g/cm^3). This bulk density compares well with a previous investigation that measured soil bulk density to range from 1.1 to 2.4 g/cm^3 (Webb et al, 1993).

The estimated annual soil erosion depths ranged from about 0.0001 millimeters (mm) in Woman Creek to 0.03 mm in Walnut Creek. Annual soil erosion in the SID drainage basin was estimated to be about .002 mm. Again, these values are influenced by large yields measured in 1995 and thus represent maximum values based on limited data. A previous study by Webb et al (1993) concluded that the annual erosion in Woman Creek was approximately 1.80 mm. This value was determined by comparing Pu-239,240 activity in Site soils in 1974 to Pu-239,240 activity measured in the same plot in 1989.

5.4 Actinide Yields for Extreme Hydrologic Events

The expected yield from extreme runoff events was evaluated by assuming a range of actinide activity in the volume of runoff water. The Rocky Flats Drainage and Flood Control Master Plan (EG&G 1992) contains modeled flood flows for the 5, 10, 25, 50, and 100-year precipitation events. The runoff water yields for these events were multiplied by a range of actinide activities in surface water to estimate the actinide transport that might be expected to occur under extreme hydrologic conditions. The estimated actinide yields for extreme hydrologic events are shown in Tables 7, 8, and 9.

5.5 Compliant Actinide Yields

The quantities of Pu-239,240 that could be discharged in compliance with RFCA water-quality standards (a.k.a. "compliant" yields) were computed by multiplying the current Pu-239,240 discharge standard of 0.15 pCi/L by the annual water yield at each station. Results of this analysis are shown in Table 10. Table 10 also shows the maximum yields for each water year for comparison with the "compliant yields." The measured maximum yields were computed by multiplying the maximum observed Pu-239,240 activity (from samples collected during the Water Year) by the annual water yield. Table 10 shows that the Site discharged less Pu-239,240 than was allowed by the discharge standard on an annual basis over the past five years.

Table 7.--Estimated Actinide Yields for Selected Hydrologic Events at Monitoring Stations in Woman Creek.

WATERSHED	GAGING STATION	LOCATION OF STATION	FLOOD RECURRENCE INTERVAL, & PRECIPITATION (INCHES)	ESTIMATED YIELD (AF)*	YIELD (LITERS)	PLUTONIUM-239,240 (μg) Assumed Activity of Water in pCi/L 0.05	0.15	0.25	0.5	0.75	1
WOMAN CREEK	GS01	Woman Creek at Indiana Street	2-YEAR, 1.6 IN.	4	4.93E+06	4	11	18	35	53	70
			10-YEAR, 2.5 IN.	48	5.92E+07	42	127	211	423	634	846
			50-YEAR, 3.4 IN.	172	2.12E+08	151	453	756	1,511	2,267	3,022
			100-YEAR, 3.8 IN.	256	3.16E+08	226	677	1,128	2,256	3,384	4,512
	GS02	Mower Ditch at Indiana Street	2-YEAR, 1.6 IN.	3.5	4.32E+06	3	9	15	31	46	62
			10-YEAR, 2.5 IN.	42.5	5.24E+07	37	112	187	374	562	749
			50-YEAR, 3.4 IN.	148	1.82E+08	130	390	650	1,300	1,950	2,599
			100-YEAR, 3.8 IN.	224	2.76E+08	197	591	985	1,969	2,954	3,939
	GS14	Woman Creek Upstream from Mower Ditch Diversion	2-YEAR, 1.6 IN.	2.5	3.08E+06	2	7	11	22	33	44
			10-YEAR, 2.5 IN.	62.5	7.71E+07	55	165	275	551	826	1,101
			50-YEAR, 3.4 IN.	248	3.05E+08	218	654	1,090	2,181	3,271	4,362
			100-YEAR, 3.8 IN.	388	4.79E+08	342	1,026	1,709	3,419	5,128	6,838
	GS07/SW029	Woman Creek at Pond C-1	2-YEAR, 1.6 IN.	1.0	1.23E+06	1	3	4	9	13	18
			10-YEAR, 2.5 IN.	38	4.69E+07	33	100	167	335	502	670
			50-YEAR, 3.4 IN.	165	2.04E+08	145	436	727	1,454	2,181	2,908
			100-YEAR, 3.8 IN.	265	3.27E+08	234	701	1,168	2,335	3,503	4,670
	GS16	Antelope Springs Creek	2-YEAR, 1.6 IN.	0	0.00E+00	0	0	0	0	0	0
			10-YEAR, 2.5 IN.	4.0	4.93E+06	4	11	18	35	53	70
			50-YEAR, 3.4 IN.	13	1.60E+07	11	34	57	115	172	229
			100-YEAR, 3.8 IN.	17	2.10E+07	15	45	75	150	225	300

[*WATER YIELDS OBTAINED FROM THE ROCKY FLATS DRAINAGE AND FLOOD CONTROL MASTER PLAN (EG&G, 1992)]

Table 8.--Estimated Actinide Yields for Selected Hydrologic Events at Monitoring Stations in Walnut Creek.

WATERSHED	GAGING STATION	LOCATION OF STATION	FLOOD RECURRENCE INTERVAL, & PRECIPITATION (INCHES)	ESTIMATED YIELD (AF)*	YIELD (LITERS)	PLUTONIUM-239,240 (μg) Assumed Activity of Water in pCi/L 0.05	0.15	0.25	0.5	0.75	1
WALNUT CREEK	GS03	Walnut Creek at Indiana Street	2-YEAR, 1.6 IN.	42	5.18E+07	37	111	185	370	555	740
			10-YEAR, 2.5 IN.	118	1.46E+08	104	312	520	1,040	1,560	2,080
			50-YEAR, 3.4 IN.	232	2.86E+08	204	613	1,022	2,044	3,066	4,089
			100-YEAR, 3.8 IN.	296	3.65E+08	261	782	1,304	2,608	3,912	5,216
	GS09 (Immediately Downstream from GS10)	Inflow to Pond B-5	2-YEAR, 1.6 IN.	22	2.71E+07	19	58	97	194	291	388
			10-YEAR, 2.5 IN.	40	4.93E+07	35	106	176	352	529	705
			50-YEAR, 3.4 IN.	61	7.53E+07	54	161	269	538	806	1,075
			100-YEAR, 3.8 IN.	71	8.76E+07	63	188	313	626	938	1,251
	GS13 / SW093	Inflow to Pond A-3 subtracting WA11	2-YEAR, 1.6 IN.	1	1.23E+06	1	3	4	9	13	18
			10-YEAR, 2.5 IN.	7	8.64E+06	6	19	31	62	93	123
			50-YEAR, 3.4 IN.	15	1.85E+07	13	40	66	132	198	264
			100-YEAR, 3.8 IN.	18	2.22E+07	16	48	79	159	238	317

[*WATER YIELDS OBTAINED FROM THE ROCKY FLATS DRAINAGE AND FLOOD CONTROL MASTER PLAN (EG&G, 1992)]

Table 9.--Estimated Actinide Yields for Selected Hydrologic Events at Monitoring Stations in the South Interceptor Ditch.

WATERSHED	GAGING STATION	LOCATION OF STATION	FLOOD RECURRENCE INTERVAL, & PRECIPITATION (INCHES)	ESTIMATED YIELD (AF)*	YIELD LITERS	PLUTONIUM-239,240 (μg) Assumed Activity of Water in pCi/L 0.05	0.15	0.25	0.5	0.75	1
SOUTH INTERCEPTOR DITCH	SW027	Pond C-2 Inflow	2-YEAR, 1.6 IN.	4	4.93E+06	4	11	18	35	53	70
			10-YEAR, 2.5 IN.	15	1.85E+07	13	40	66	132	198	264
			50-YEAR, 3.4 IN.	32	3.95E+07	28	85	141	282	423	564
			100-YEAR, 3.8 IN.	40	4.93E+07	35	106	176	352	529	705

[*WATER YIELDS OBTAINED FROM THE ROCKY FLATS DRAINAGE AND FLOOD CONTROL MASTER PLAN (EG&G, 1992)]

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Table 10.-- Comparison of Estimated "Compliant" Maximum Annual Plutonium-239,240 Yields with Maximum Measured Yields for Each Water Year

(Total Maximum Annual Yield Estimations Made Assuming Discharged Water Always Has a Hypothetical, Constant Activity of 0.15 pCi/Liter)

WATER YEAR	GAGING STATION	MEASURED ANNUAL RUNOFF YIELD (AF)	ESTIMATED MAXIMUM ANNUAL Pu-239,240 YIELD if All Water had 0.15 pCi/L Pu (µg/yr)	MAXIMUM MEASURED ANNUAL Pu-239,240 YIELD[1] (µg/yr)
1993	GS01+ GS02	90	238	32
1994	GS01+ GS02	58	153	2
1995	GS01+ GS02	905	2,392	30[2]
1997	GS01	284	751	20
1993	GS03	49	130	15
1994	GS03	89	235	8
1995	GS03	1405	3,715	150
1996	GS03	176	465	22
1997	GS03	482	1,274	397

1) Computation assumes all water had the maximum Pu-239,240 activity measured at each station for each water year.
2) Measurement of Pu-239,240 for GS02 in WY95 used for GS01

The preliminary results indicate that current soil activity in the Woman Creek and Walnut Creek drainages might be at a level that does not adversely impact surface-water quality on an annual basis when considered from a annual total yield perspective. However, the RFCA regulates the Site by comparison of the 30-day moving average Pu-239,240 and Am-241 activities to the 0.15 pCi/L standard for each actinide and does not incorporate the concept of total actinide yeilds into its regulatory framework.

5.6 Runoff Coefficients

The runoff coefficients for selected Site drainage basins were computed by dividing the annual volume of precipitation that fell on the drainage basins by the annual water yield measured at the downstream-most point in the basins (Equation 3). Estimated runoff coefficients for selected Site drainage basins are shown in Tables 11, 12, and 13.

<u>Equation 3:</u>

$$\text{Runoff Coefficient for Basin} = (P_B \times DA_B) / AY_B$$

where:

P_B = Annual total precipitation depth in basin,
DA_B = Drainage basin area, and
AY_B = Annual total runoff yield in the basin.

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The drainage basin slope, percent vegetative cover, cover type, soil characteristics, land use characteristics, and other conditions will affect the value of the runoff coefficient, and the soil erosion and associated actinide transport characteristics as well. The runoff coefficient calculated herein will be used to calibrate the hydrologic components of the WEPP erosion model.

Table 11.-- Runoff Coefficient Determination for Selected Woman Creek Gaging Stations.

WATER YEAR	GAGING STATION	DRAINAGE AREA (AC)	MEASURED TOTAL ANNUAL PRECIPITATION (FT)	ESTIMATED POTENTIAL TOTAL ANNUAL YIELD (AF)	MEASURED ANNUAL YIELD (AF)	ESTIMATED RUNOFF COEFFICIENT
1993	GS01+ GS02		0.88	1,365	90	0.07
1994	GS01+ GS02	1545	0.91	1,400	58	0.04
1995	GS01+GS02		1.48	2,283	905	0.40
1996	GS01	1364	1.02	1,396	34	0.02
1997	GS01		1.20	1,631	284	0.17
					AVERAGE:	**0.08**
1993	GS14		0.88	789	*73*	*0.09*
1994	GS14		0.91	809	122	0.15
1995	GS14	893	1.48	1,319	401	0.30
					AVERAGE:	**0.12**
1993	GS07		0.88	712	186	0.26
1994	GS07	806	0.91	730	135	0.18
1995	SW029		1.48	1,191	1238	1.04
1996	SW029		1.02	825	152	0.18
					AVERAGE:	**0.21**
1993	GS16		0.88	119	35	0.29
1994	GS16		0.91	122	28	0.23
1995	GS16	135	1.48	199	103	0.51
1996	GS16		1.02	138	66	0.48
1997	GS16		1.20	161		
					AVERAGE:	**0.33**
1994	GS18	501	0.91	454	46	0.10
1995	GS18		1.48	740	*161*	*0.22*
					AVERAGE:	**0.10**

Notes:
1) Values in Italics based on partial record at GS14, GS18.
2) AVERAGE runoff coefficient values do not include water year 1995 data due to extreme hydrologic conditions in spring of 1995.

Table 12.-- Runoff Coefficient Determination for South Interceptor Ditch Gaging Stations.

WATER YEAR	GAGING STATION	DRAINAGE AREA (AC)	MEASURED ANNUAL TOTAL PRECIPITATION (FT)	ESTIMATED POTENTIAL ANNUAL TOTAL YIELD (AF)	MEASURED ANNUAL YIELD (AF)	COMPOSITE BASIN ESTIMATED RUNOFF COEFFICIENT
1995	SW027		1.48	275	63	0.23
1996	SW027	186	1.02	190	15.5	0.08
1997	SW027		1.20	222	22	0.10
					AVERAGE:	**0.14**
1995	GS21		1.48	3.9	*2.5*	0.64
1996	GS21	2.66	1.02	2.7	1.1	0.40
					AVERAGE:	**0.52**
1995	GS22		1.48	20.8	*19.7*	0.95
1996	GS22	14.1	1.02	14.4	10.9	0.76
					AVERAGE:	**0.85**
1995	GS24		1.48	8.6	*1.6*	0.19
1996	*GS24*	5.84	1.02	6.0	0.63	0.11
					AVERAGE:	**0.15**
1995	GS25		1.48	9.9	*7*	0.71
1996	GS25	6.7	1.02	6.9	2.2	0.32
					AVERAGE:	**0.51**

Notes:
1) Values in italics for water year 1995 are estimated based on 6 months of continuous record.
2) Values for GS22 measured yield do not include baseflow of approximately 0.025 cfs.

Table 13.--Runoff Coefficient Determination for Selected Walnut Creek Gaging Stations.

WATER YEAR	GAGING STATION	DRAINAGE AREA (AC)	MEASURED ANNUAL TOTAL PRECIPITATION (FT)	ESTIMATED POTENTIAL ANNUAL TOTAL YIELD (AF)	MEASURED ANNUAL YIELD (AF)	ESTIMATED RUNOFF COEFFICIENT
1993	GS03		0.88	872	49	0.06
1994	GS03		0.91	894	89	0.10
1995	GS03	*987	1.48	1,458	1405	0.96
1996	GS03		1.02	1,010	176	0.17
1997	GS03		1.20	1,180	482	0.41
					AVERAGE:	**0.18**
1993	GS10		0.88	159	41	0.26
1994	GS10		0.91	163	60	0.37
1995	GS10	180	1.48	266	154	0.58
1996	GS10		1.02	184	88	0.48
1997	GS10		1.20	215	110	0.51
					AVERAGE:	**0.40**
1993	GS13		0.88	220	69	0.31
1994	SW093	249	0.91	226	59	0.26
1995	SW093		1.48	368	234	0.64
1996	SW093		1.02	255	80	0.31
1997	SW093		1.20	298	136	0.46
					AVERAGE:	**0.34**

NOTES:
1) * Measured annual yield for GS03 adjusted by subtracting out wastewater treatment plant yield.
2) AVERAGE runoff coefficient values do not include water year 1995 data due to extreme hydrologic conditions in spring of 1995.

5.7 Summary of Results

5.7.1 Woman Creek Results

Evaluation of the load and yield estimates for Woman Creek in Table 4 indicate that approximately 38 μg of Pu-239,240 and 105 μg of Am-241 are annually discharged off-Site through Woman Creek. Larger quantities of uranium (2,621 grams) are discharged off-Site due to its natural occurrence in the region and solubility. These quantities of actinides combined with about 2,265 kilograms of sediment are discharged to the Woman Creek Reservoir facility each year.

Most of the sediment discharge from Woman Creek likely comes from erosion of Buffer Zone Roads. Table 4 shows that about 7,440 kilograms of sediment are annually moved past the GS16 gage on Antelope Springs Gulch. Most of this material is suspected to come from a firebreak road located immediately upstream from the gage. Comparison of the GS16 TSS yield to the yield at GS07/SW029 indicates that about 80 percent of the GS16 sediment is trapped in Pond C-1 on Woman Creek.

Comparison of annual yields at GS07/SW029 (Pond C-1 outlet) and GS14 (Woman Creek below Pond C-2) reveals that about 67 percent of the solids passing through Pond C-1 are removed in the thickly vegetated channel of the Woman Creek Bypass that routes Woman Creek around Pond C-2. However, there are very few data from GS14 to support this conclusion.

Table 11 shows that very little precipitation runoff occurs in the Woman Creek watershed. Runoff coefficients for Woman Creek were calculated to be between about 0.1 and 0.3, the highest value being for GS16, which receives firebreak road runoff.

The analysis resulted in an estimated erosion rate of 0.0002 mm per year for the Woman Creek drainage. However, this value applies to the entire GS01 and GS02 drainage and does not account for the fact that most of the watershed erosion occurs on disturbed areas and roads. These results might explain why very little actinide activity is measured in Woman Creek at GS01 (Woman Creek at Indiana Street).

5.7.2 South Interceptor Ditch Results

Only one gaging station (SW027) has been installed on the SID. All of the other gaging stations, in the SID watershed, are located on major tributaries to the SID. Table 5 and Figures 4, and 5 show that about 90 percent of the solids entering the SID between the 460 culvert (GS22) and the Building 881 Hillside (GS21, GS24, and GS25) are removed by deposition in the SID channel.

Some smaller tributary inflows occur east of the 881 Hillside that were not measured for this study. These tributaries are:

1) Two channels that route inner Industrial Area perimeter road runoff to the SID,
2) A road that once supported traffic from the East Access Road to Pond C-1 which was revegetated in 1996, and
3) A channel that carries East Access Road runoff to the eastern end of the SID. These tributaries are being evaluated with the WEPP model.

A new monitoring station (GS42) was installed this year to measure runoff and constituent yields from the eastern most tributary ((3) above).

Not withstanding the unmeasured tributary inflows, the data indicate that the SID is filling with sediment and thus limiting transport of suspended solids and associated radionuclides. The WEPP model will be calibrated to predict similar sediment deposition in the SID channel.

The data show that approximately 447 μg of Pu-239,240, 78 μg of Am-241, and 250 kg of U are annually discharged to Pond C-2. It appears that nearly all of this material is settling out of the water column in Pond C-2 due to the fact that the quantity of Pu-239,240 measured in Woman Creek at GS01 is an order of magnitude lower than the quantity discharged to Pond C-2. Approximately 2,650 kilograms of sediment are annually discharged to Pond C-2. The estimated soil erosion rate in the SID drainage is about 0.002 mm, and the runoff coefficient is estimated to be about 0.14 for the entire sub-basin. Therefore, actinide transport due to soil erosion in the SID watershed appears to be small.

5.7.3 Walnut Creek Results

Evaluation of Table 6 and Figures 6 and 7 reveals the effectiveness of the detention ponds for removing suspended solids and associated Pu-239,240 and Am-241 from Site surface water. Stations GS10 and SW093/GS13 are located upstream from the detention ponds, and station GS03 is located downstream on Walnut Creek at Indiana Street. The data show that the ponds remove about 85 percent of the TSS, Pu-239,240, and Am-241 from the Site runoff. However, the ponds are less effective at U removal as shown in Figure 7. This is likely due to U transport as a dissolved constituent.

The data show that approximately 131 μg of Pu-239,240, 99 μg of Am-241, and 2 kg of U are annually discharged off Site at GS03. Approximately 12,300 kilograms of sediment are annually discharged off-Site in Walnut Creek. The runoff coefficient is estimated to be about 0.18 for the entire Walnut Creek watershed, and estimated soil erosion rate in the Walnut Creek watershed is about 0.01 mm. Therefore, actinide transport due to soil erosion in the Walnut Creek watershed appears to be small.

5.8 Sensitivity Analysis

The computation of loads and yields is sensitive to the variability of the flow measurements and the radiochemical measurements and to the assumptions made in selecting representative measurements for the observed range of hydrologic conditions. The discharge and radiochemical measurements both vary by orders of magnitude. The loading computations were evaluated to determine which component (i.e. flow or activity (concentration)) controls the sensitivity in the calculations. For example, if flow varies over an order of magnitude, but activities vary only by a factor of two, then the calculation of load and yield was more sensitive to the flow measurements than the radiochemical measurements.

Results of the sensitivity analysis are shown in Table 14. There is no single variable or set of variables that consistently control the sensitivity of the load and yield calculations. Therefore, it is important to control the quality of the flow measurements and radionuclide and TSS measurements because all of the measurements can vary over several orders of magnitude.

Table 14.-- Relative Sensitivity of Loading Calculations to Independent Variables

GAGING STATION	APPROXIMATE VARIABILITY OF MEASUREMENTS (ORDERS OF MAGNITUDE)				
	Pu-239,240 Activity	Am-241 Activity	U Activity	TSS Concentration	Flow
GS01	2	2	3	2	4
GS02	2	3	2	2	3
GS03	3	3	0.1	1.5	3.8
GS07 / SW029	2	3	1	1	1
GS10	3.5	3	2.4	2.5	2.4
GS16	1	1	1	3	1
GS17	3	2	0.75	2.5	1.5
GS18	1	1	1	1	2
GS21	1.5	0.9	2.5	2.25	1.5
GS22	1.6	1	1	1.25	1
GS24	1.3	0.25	1.25	2.25	0.5
GS25	1	0.5	0.75	1.5	2
SW027	2.75	3	0.2	2.2	2.25
GS13 / SW093	2	3.8	1	2.5	1.5

Notes: 1) Pu-239,240 = plutonium-239,240; 2) Am-241 = americium-241,
3) U = uranium-233,234 + uranium-235 + uranium-238;
4) TSS = total suspended solids;

6.0 References

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Appendices

Appendix 1 - Comparison of Duplicate Total Suspended Solids Sample Analysis Results for Uncertainty Calculation.

LOCATION	SAMPLENO	COLLECTION DATE	RESULT TYPE	RESULT	UNITS	DETECTION LIMIT	RELATIVE ABSOLUTE % DIFF.
GS05	SW00554GS	11/14/94	DUPLICATE	5	mg/L	5	
GS05	SW00554GS	11/14/94	REAL SAMPLE	8	mg/L	5	37.5%
GS07	SW70157JE	10/17/93	DUPLICATE	7	mg/L	5	
GS07	SW70157JE	10/17/93	REAL SAMPLE	7	mg/L	5	0.0%
GS09	SW00532GS	9/21/94	DUPLICATE	27	mg/L	5	3.8%
GS09	SW00532GS	9/21/94	REAL SAMPLE	26	mg/L	5	
GS09	SW00541GS	10/17/94	REAL SAMPLE	45	mg/L	5	
GS09	SW00544GS	10/17/94	REAL SAMPLE	30	mg/L	5	50.0%
GS09	SW00532GS	9/21/94	DUPLICATE	27	mg/L	5	
GS09	SW00532GS	9/21/94	REAL SAMPLE	26	mg/L	5	3.8%
GS09	SW00527GS	8/31/94	REAL SAMPLE	35	mg/L	5	
GS09	SW00527GS	8/31/94	DUPLICATE	36	mg/L	5	2.8%
GS10	SW00516GS	6/20/94	REAL SAMPLE	180	mg/L	5	
GS10	SW00516GS	6/20/94	DUPLICATE	170	mg/L	5	5.9%
GS11	SW00520GS	6/20/94	DUPLICATE	6	mg/L	5	
GS11	SW00520GS	6/20/94	REAL SAMPLE	5	mg/L	5	20.0%
GS11	SW00522GS	7/23/94	REAL SAMPLE	19	mg/L	5	
GS11	SW00522GS	7/23/94	DUPLICATE	21	mg/L	5	9.5%
GS14	SW70158JE	10/17/93	REAL SAMPLE	5	mg/L	5	
GS14	SW70158JE	10/17/93	DUPLICATE	5	mg/L	5	0.0%
GS17	SW00550GS	11/5/94	DUPLICATE	15	mg/L	5	
GS17	SW00550GS	11/5/94	REAL SAMPLE	15	mg/L	5	0.0%
GS22	SW00340EG	6/28/95	DUPLICATE	120	mg/L	5	
GS22	SW00340EG	6/28/95	REAL SAMPLE	110	mg/L	5	9.1%
GS27	SW00344EG	6/28/95	REAL SAMPLE	1500	mg/L	5	
GS27	SW00344EG	6/28/95	DUPLICATE	1800	mg/L	5	16.7%
			Average Relative Percent Difference (Uncertainty):				**12.2%**

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1993 - 1997 AT GS01

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	7.18E-01	178%	4.54E-02	182%	2.69E+00	22%	5,424	22%
AVERAGE	5.12E-02		4.95E-03		1.42E+00		3,033	
MINIMUM	0.00E+00		5.87E-05		1.02E-01		642	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1993 - 1997 AT GS01

Water Year	ESTIMATED AVERAGE ANNUAL YIELDS			
	Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
1993 - 1997	20	23	1,751	412

SUMMARY OF ACTINIDE YIELDS FOR 1991 - 1997 AT GS01

Water Year	ESTIMATED AVERAGE ANNUAL YIELDS			
	Pu-239,240 (μg)	Am-241 (μg)	U-total (g)	TSS (kg)
1991	19	59	857	-
1992	59	26	2,476	-
1993	3	-	111	34
1994	1	0.4	148	-
1996	-	7	393	789
1997	20	23	6,523	-

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1991 - 1994 AT GS02

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	8.70E-02	138%	9.19E-02	168%	4.67E-01	27%	10,721	22%
AVERAGE	3.31E-02		3.11E-02		2.03E-01		3,733	
MINIMUM	2.91E-05		3.50E-06		5.40E-03		5	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1991 - 1994 AT GS02

Water Year	Annual Days with Flow	ESTIMATED AVERAGE ANNUAL YIELDS			
		Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
1991-1995	152	17	81	870	1,854

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1993 - 1996 AT GS16

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	1.17E-02	325%	6.09E-03	155%	4.95E-02	80%	16,428	22%
AVERAGE	2.46E-03		1.04E-03		1.31E-02		3,864	
MINIMUM	0.00E+00		0.00E+00		4.80E-04		34	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1993 - 1996 AT GS16

	ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1993 - 1996	5	6	34	7,440

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR 1994 - 1997 AT GS16

		ESTIMATED LOADS AND ASSOCIATED ERROR							
Water Year	Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
1993	MAXIMUM	1.17E-02	376%	6.09E-03	158%	2.28E-02	77%	1.64E+04	22%
	AVERAGE	3.27E-03		1.21E-03		9.93E-03		4.72E+03	
	MINIMUM	0.00E+00		0.00E+00		5.29E-04		3.42E+01	
1994 - 1996	MAXIMUM	1.89E-03	235%	9.09E-04	210%	4.95E-02	90%	5.83E+03	22%
	AVERAGE	6.37E-04		4.68E-04		2.06E-02		1.93E+03	
	MINIMUM	0.00E+00		2.62E-05		4.80E-04		5.71E+01	

SUMMARY OF ACTINIDE YIELDS FOR 1994 - 1997 AT GS16

		ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Days with Flow	Pu-239,240 (µg)	Am-241 (µg)	U-total (g)	TSS (kg)
1993	365	3	3	8	3548
1994 - 1996	365	6	9	59	11333

GS18 LOAD DATA

DATE	PU LOAD (μg/hr)	PU LOAD ERROR (%)	AM LOAD (μg/hr)	LOAD ERR (%)	U LOAD (g/hr)	U LOAD ERROR (%)	TSS LOAD (grams/hr)	LOAD ERROR (%)
930517	9.72E-03	114%	0.00E+00		5.68E-02	32%	2,777.58	22%
930617	4.37E-05	52%	8.39E-06	235%	3.33E-04	44%		
931017	0.00E+00	10%	4.20E-04	85%	1.62E-02	62%	214.10	22%

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1993 - 1994 AT GS18

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	9.72E-03		4.20E-04		5.68E-02		2,778	
AVERAGE	3.25E-03	59%	1.43E-04	160%	2.44E-02	46%	1,496	22%
MINIMUM	0.00E+00		0.00E+00		3.33E-04		214	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1993 - 1994 AT GS18

Water Year	Days with Flow	ESTIMATED AVERAGE ANNUAL YIELDS			
		Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
1993 - 1994	165	3	6	41	1,040

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1993 - 1995 AT GS17

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	7.96E-01	238%	5.06E-02	80%	1.28E-01	37%	17,710	22%
AVERAGE	1.00E-01		6.71E-03		5.18E-02		3,646	
MINIMUM	0.00E+00		0.00E+00		1.95E-03		7	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1993 - 1995 AT GS17

		ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Days with Flow	Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
1993 - 1995	340	1,490	396	325	41,309

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1991 - 1994 AT GS07 / SW029

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	7.47E-02		3.03E-01		8.25E-01		2.12E+03	
AVERAGE	2.08E-02	92%	5.26E-02	142%	2.75E-01	64%	8.84E+02	22%
MINIMUM	0.00E+00		3.06E-04		3.95E-02		1.78E+02	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1991 - 1994 AT GS07 / SW029

Water Year	ESTIMATED AVERAGE ANNUAL YIELDS			
	Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1991 - 1994	43	181	593	2,020

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1991 - 1997 AT GS14

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	3.07E-03	435%	2.80E-04	210%	2.28E-01	30%	376	22%
AVERAGE	1.54E-03		1.40E-04		1.78E-01		290	
MINIMUM	0.00E+00		0.00E+00		1.28E-01		204	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1991 - 1997 AT GS14

Water Year	Days with Flow	ESTIMATED AVERAGE ANNUAL YIELDS			
		Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1993	172	5	0	212	622
1994	219	0	4	846	750
Averages:	196	3	2	529	686

APPENDIX B-1

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 - 1996 AT GS21

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	4.79E-02		4.66E-03		1.62E-01		2.47E+04	
AVERAGE	1.18E-02	28%	1.54E-03	30%	2.99E-02	23%	4.28E+03	22%
MINIMUM	1.22E-04		0.00E+00		0.00E+00		1.14E+01	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS21

	ESTIMATED AVERAGE ANNUAL YIELDS			
Water Years	Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1995* / 1996	1	1	2	271

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 AT GS21

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	2.52E-02		4.64E-03		3.12E-02		5.89E+03	
AVERAGE	1.08E-02	41%	2.16E-03	37%	1.40E-02	21%	2.93E+03	22%
MINIMUM	9.38E-04		2.23E-04		1.65E-03		2.50E+02	

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1996 AT GS21

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	4.79E-02		4.66E-03		1.62E-01		2.47E+04	
AVERAGE	1.25E-02	18%	1.05E-03	24%	4.26E-02	25%	5.37E+03	22%
MINIMUM	1.22E-04		0.00E+00		0.00E+00		1.14E+01	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS21

		ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Days with Flow	Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1995*	89	2	1	2	384
1996	76	0.5	0.4	3	158

*Note: Monitoring at GS21 began in April 1995.

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 - 1996 AT GS24

Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
	ESTIMATED LOADS AND ASSOCIATED ERROR							
MAXIMUM	6.03E-02		3.63E-03		3.70E-02		1.78E+04	
AVERAGE	1.30E-02	26%	9.40E-04	46%	8.62E-03	16%	3.01E+03	22%
MINIMUM	1.52E-04		5.60E-06		1.39E-04		7.26E+00	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS24

Water Years	Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
	ESTIMATED AVERAGE ANNUAL YIELDS			
1995* / 1996	1	0.4	1	333

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 AT GS24

Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
	ESTIMATED LOADS AND ASSOCIATED ERROR							
MAXIMUM	6.03E-02		3.32E-03		3.70E-02		1.78E+04	
AVERAGE	2.33E-02	23%	1.39E-03	38%	1.66E-02	16%	6.90E+03	22%
MINIMUM	1.68E-03		2.41E-04		4.10E-03		1.06E+03	

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1996 AT GS24

Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
	ESTIMATED LOADS AND ASSOCIATED ERROR							
MAXIMUM	3.43E-02		1.59E-03		2.25E-02		8.60E+03	
AVERAGE	9.11E-03	27%	5.34E-04	50%	5.62E-03	16%	1.56E+03	22%
MINIMUM	1.52E-04		5.60E-06		1.39E-04		7.26E+00	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS24

Water Year	Days with Flow	Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
		ESTIMATED AVERAGE ANNUAL YIELDS			
1995*	47	2	0.5	2	487
1996	110	0.9	0.3	1	180

Note: Monitoring at GS24 began in April 1995.

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 - 1996 AT GS25

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	**Pu-239,240 (μg/hr)**	**Error**	**Am-241 (μg/hr)**	**Error**	**U-total (g/hr)**	**Error**	**Total Suspended Solids (grams/hr)**	**Error**
MAXIMUM	6.25E-02		1.18E-02		9.39E-02		2.49E+04	
AVERAGE	1.60E-02	42%	2.71E-03	53%	3.53E-02	17%	6.75E+03	22%
MINIMUM	1.44E-04		2.31E-05		0.00E+00		3.03E+01	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS25

	ESTIMATED AVERAGE ANNUAL YIELDS			
Water Years	Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
1995* / 1996	1	1	7	401

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 AT GS25

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	**Pu-239,240 (μg/hr)**	**Error**	**Am-241 (μg/hr)**	**Error**	**U-total (g/hr)**	**Error**	**Total Suspended Solids (grams/hr)**	**Error**
MAXIMUM	6.25E-02		1.18E-02		8.84E-02		1.89E+04	
AVERAGE	2.48E-02	28%	4.22E-03	37%	6.13E-02	16%	6.73E+03	22%
MINIMUM	5.62E-03		4.05E-04		3.55E-02		4.92E+02	

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1996 AT GS25

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	**Pu-239,240 (μg/hr)**	**Error**	**Am-241 (μg/hr)**	**Error**	**U-total (g/hr)**	**Error**	**Total Suspended Solids (grams/hr)**	**Error**
MAXIMUM	3.63E-02		5.81E-03		9.39E-02		2.49E+04	
AVERAGE	9.48E-03	65%	1.58E-03	76%	2.22E-02	19%	6.77E+03	22%
MINIMUM	1.44E-04		2.31E-05		0.00E+00		3.03E+01	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS25

		ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Days with Flow	Pu-239,240 (μg)	Am-241(μg)	U-total (g)	TSS (kg)
1995*	146	2	1	11	359
1996	231	0.46	0.37	3	442

*Note: Monitoring at GS25 began in April 1995.

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SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS22

Water Years	ESTIMATED AVERAGE ANNUAL YIELDS			
	Pu-239,240 (µg	Am-241(µg)	U-total (g)	TSS (kg)
1995* / 1996	4	12	34	5,657

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 AT GS22

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	4.94E-02		2.53E-02		3.32E-01		4.97E+04	
AVERAGE	2.44E-02	69%	1.23E-02	47%	1.78E-01	18%	1.89E+04	22%
MINIMUM	5.96E-03		5.01E-03		5.76E-02		3.89E+03	

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1996 AT GS22

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	3.37E-02		1.12E-02		1.32E-01		3.35E+04	
AVERAGE	1.87E-02	25%	3.88E-03	55%	7.93E-02	14%	2.16E+04	22%
MINIMUM	2.27E-03		1.36E-04		7.02E-03		1.15E+03	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1996 AT GS22

Water Year	Days with Flow	ESTIMATED AVERAGE ANNUAL YIELDS			
		Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1995*	365	3	14	35	2,428
1996	366	4	11	33	8,887

Note: Monitoring at GS22 began in April 1995.

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1995 - 1997 AT SW027

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	1.71E+01		7.20E-01		8.35E+00		5.50E+04	
AVERAGE	1.17E+00	55%	5.57E-02	94%	7.42E-01	29%	9.69E+03	22%
MINIMUM	0.00E+00		0.00E+00		1.98E-02		1.91E+01	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1997 AT SW027

	ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Pu-239,240 (μg	Am-241(μg)	U-total (g)	TSS (kg)
1995	1,305	223	614	4,961
1996	22	6	81	347
1997	12	4	55	
AVERAGE:	447	78	250	2,654

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEAR 1995 AT SW027

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	1.71E+01		7.20E-01		8.35E+00		5.50E+04	
AVERAGE	5.82E+00	51%	2.69E-01	33%	2.76E+00	21%	2.69E+04	22%
MINIMUM	1.38E-03		9.08E-04		1.06E-01		1.44E+02	

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEAR 1996 AT SW027

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	1.04E+00		5.98E-02		8.32E-01		1.33E+04	
AVERAGE	2.07E-01	28%	1.36E-02	38%	3.70E-01	16%	2.97E+03	22%
MINIMUM	1.50E-03		0.00E+00		4.63E-02		1.91E+01	

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEAR 1997 AT SW027

	ESTIMATED LOADS AND ASSOCIATED ERROR					
Statistic	Pu-239,240 (μg/hr)	Error	Am-241 (μg/hr)	Error	U-total (g/hr)	Error
MAXIMUM	3.05E-01		1.01E-02		8.25E-01	
AVERAGE	1.02E-01	86%	5.19E-03	195%	3.20E-01	46%
MINIMUM	4.41E-03		2.74E-04		8.66E-02	

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1991 - 1997 AT GS13 / SW093

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	4.12E+01	94%	4.67E+00	116%	1.38E+01	28%	296,109	22%
AVERAGE	1.64E+00		2.70E-01		8.59E-01		72,172	
MINIMUM	3.35E-05		4.27E-05		2.15E-02		28	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1991 - 1997 AT GS13 / SW093

Water Years	ESTIMATED AVERAGE ANNUAL YIELDS			
	Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1991 - 1997	330	311	784	-
1991 - 1996	-	-	-	38,148

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1994 - 1997 AT SW093

Water Year	Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR							
		Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
1994	MAXIMUM	1.61E+01	18%	1.32E+00	27%	1.42E+00	41%	227,995	22%
	AVERAGE	5.77E+00		6.08E-01		6.85E-01		142,513	
	MINIMUM	2.17E-02		6.95E-03		2.03E-01		5,065	
1995	MAXIMUM	2.13E+01	29%	4.67E+00	27%	2.26E+00	21%	257,326	22%
	AVERAGE	4.95E+00		1.18E+00		1.23E+00		103,573	
	MINIMUM	4.10E-02		9.85E-03		4.34E-01		27,603	
1996	MAXIMUM	4.54E+00	28%	5.53E-01	31%	2.69E+00	17%	296,109	22%
	AVERAGE	8.10E-01		1.06E-01		7.16E-01		58,725	
	MINIMUM	4.00E-03		1.33E-03		1.29E-01		97	
1997	MAXIMUM	4.12E+01	138%	4.66E+00	119%	1.38E+01	26%	No TSS Data in WY-97	No TSS Data in WY-97
	AVERAGE	1.39E+00		1.82E-01		9.04E-01			
	MINIMUM	3.35E-05		4.27E-05		2.15E-02			

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1995 - 1997 AT SW093

Water Year	ESTIMATED AVERAGE ANNUAL YIELDS			
	Pu-239,240 (µg)	Am-241 (µg)	U-total (g)	TSS (kg)
1991	33	39	693	27,832
1992	64	92	1,953	117,363
1993	103	38	360	8,796
1994	60	57	468	16,981
1995	1,716	1,761	637	45,523
1996	143	87	346	12,394
1997	190	101	1,034	-

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1991 - 1997 AT GS10

	ESTIMATED LOADS AND ASSOCIATED ERROR							
Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	3.97E+01		5.99E+00		1.09E+01		1,083,147	
AVERAGE	1.48E+00	43%	3.15E-01	40%	7.92E-01	34%	116,262	22%
MINIMUM	5.83E-04		4.28E-04		5.40E-03		124	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1991 - 1997 AT GS10

	ESTIMATED AVERAGE ANNUAL YIELDS			
Water Years	Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1991 - 1997	281	268	78	
1991 - 1996				20,185

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1994 - 1997 AT GS10

		ESTIMATED LOADS AND ASSOCIATED ERROR							
Water Year	Statistic	Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
	MAXIMUM	8.72E+00		1.49E+00		2.95E+00		614,771	
1994	AVERAGE	2.30E+00	20%	4.05E-01	23%	8.84E-01	40%	179,625	22%
	MINIMUM	2.25E-02		8.40E-03		3.54E-02		1,510	
	MAXIMUM	7.62E+00		2.08E+00		6.20E+00		611,685	
1995	AVERAGE	1.65E+00	22%	4.41E-01	25%	1.53E+00	26%	119,830	22%
	MINIMUM	9.78E-02		1.98E-02		1.84E-01		2,083	
	MAXIMUM	7.43E+00		2.19E+00		3.88E+00		1,083,147	
1996	AVERAGE	1.73E+00	44%	4.30E-01	23%	1.09E+00	17%	238,706	22%
	MINIMUM	6.77E-04		1.56E-02		7.75E-02		663	
	MAXIMUM	3.97E+01		5.99E+00		1.09E+01			
1997	AVERAGE	2.21E+00	41%	3.79E-01	39%	8.31E-01	27%	No TSS Data in WY-97	No TSS Data in WY-97
	MINIMUM	5.83E-04		4.28E-04		5.40E-03			

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1994 - 1997 AT GS10

	ESTIMATED AVERAGE ANNUAL YIELDS			
Water Year	Pu-239,240 (µg)	Am-241 (µg)	U-total (g)	TSS (kg)
1991	3	1	83	6,650
1992	211	291	199	669
1993	95	93	30	11,506
1994	558	389	76	39,674
1995	419	448	41	26,597
1996	281	302	18	36,014
1997	401	355	95	-

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SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1991 - 1997 AT GS03

Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
MAXIMUM	1.00E+00		1.45E-01		3.74E+00		13,768	
AVERAGE	4.95E-02	213%	8.43E-03	162%	5.61E-01	31%	3,158	22%
MINIMUM	0.00E+00		0.00E+00		0.00E+00		445	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1991 - 1997 AT GS03

Water Year	Average Number Days with Flow	ESTIMATED AVERAGE ANNUAL YIELDS Pu-239,240 (µg)	Am-241(µg)	U-total (g)	TSS (kg)
1992 - 1997	#REF!	131	99	2,061	12,264

SUMMARY OF ESTIMATED ACTINIDE LOADS FOR WATER YEARS 1992 - 1997 AT GS03

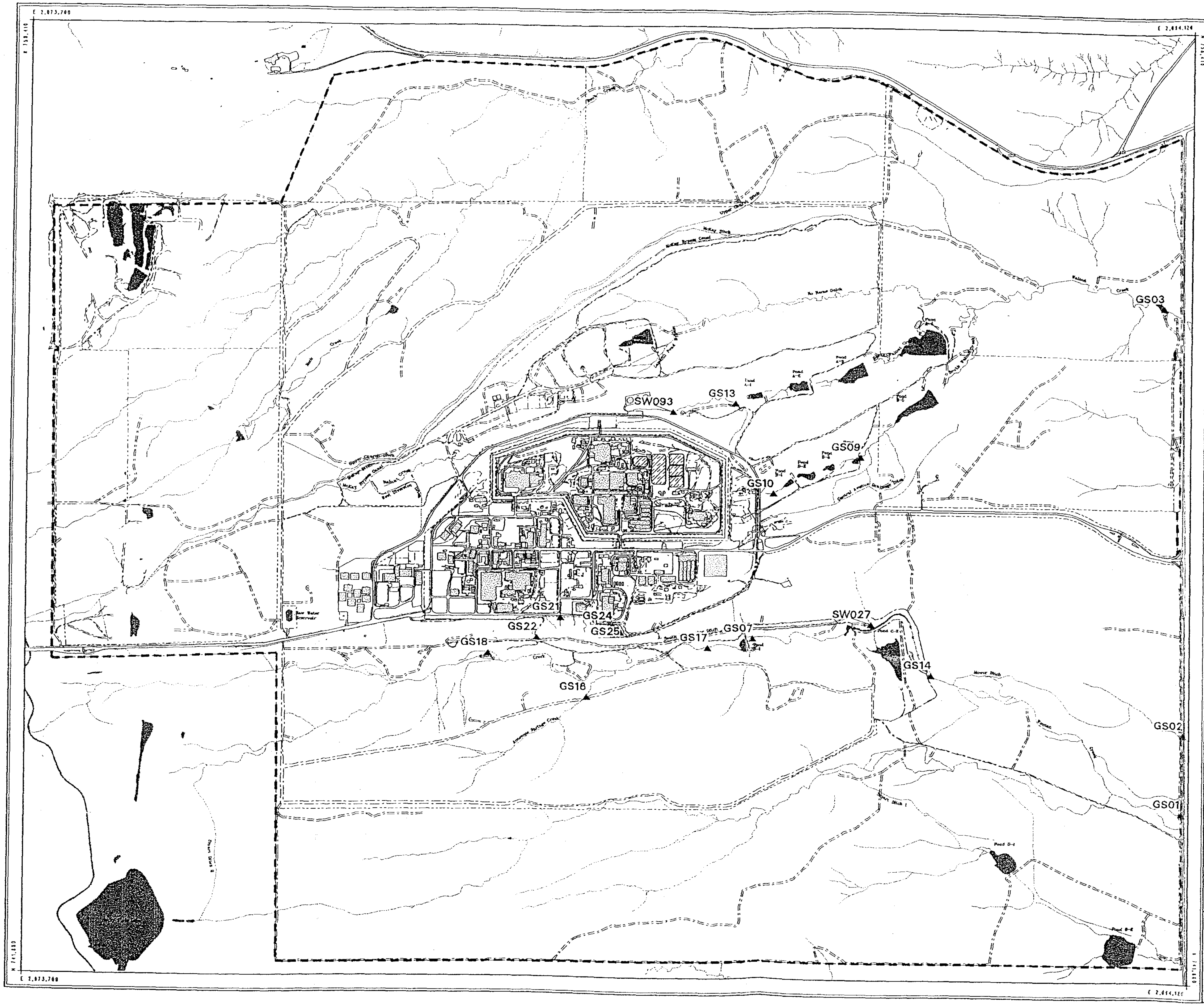
Water Year	Statistic	ESTIMATED LOADS AND ASSOCIATED ERROR Pu-239,240 (µg/hr)	Error	Am-241 (µg/hr)	Error	U-total (g/hr)	Error	Total Suspended Solids (grams/hr)	Error
	MAXIMUM	6.02E-01		1.45E-01		3.04E+00			
1992	AVERAGE	5.23E-02	87%	1.16E-02	195%	6.72E-01	38%	No TSS Data	No TSS Data
	MINIMUM	0.00E+00		0.00E+00		2.64E-08			
	MAXIMUM	1.53E-02		2.66E-03		3.01E-01		1.38E+04	
1993	AVERAGE	3.28E-03	97%	7.18E-04	84%	1.02E-01	26%	6.10E+03	22%
	MINIMUM	0.00E+00		0.00E+00		3.60E-04		4.45E+02	
	MAXIMUM	5.31E-02		1.37E-02		5.23E-01			
1994	AVERAGE	1.06E-02	247%	1.84E-03	216%	2.75E-01	26%	No TSS Data	No TSS Data
	MINIMUM	0.00E+00		0.00E+00		0.00E+00			
	MAXIMUM	3.15E-01		6.96E-02		4.E+00			
1995	AVERAGE	5.13E-02	334%	1.42E-02	134%	1.E+00	23%	No TSS Data	No TSS Data
	MINIMUM	1.28E-05		0.00E+00		2.E-03			
	MAXIMUM	5.90E-02		6.71E-03				5.81E+03	
1996	AVERAGE	2.95E-02	32%	4.56E-03	10%	No U Data	No U Data	5.35E+03	22%
	MINIMUM	0.00E+00		2.40E-03				4.89E+03	
	MAXIMUM	1.00E+00		7.36E-02				2.71E+03	
1997	AVERAGE	1.33E-01	87%	1.61E-02	133%	No U Data	No U Data	1.96E+03	22%
	MINIMUM	0.00E+00		0.00E+00				7.40E+02	

SUMMARY OF ACTINIDE YIELDS FOR WATER YEARS 1992 - 1997 AT GS03

Water Year	ESTIMATED AVERAGE ANNUAL YIELDS Pu-239,240 (µg)	Am-241 (µg)	U-total (g)	TSS (kg)
1992	195	121	1,556	8,392
1993	15	17	729	20,897
1994	8	8	269	-
1995	150	205	5,688	-
1996	22	34	-	5,319
1997	397	209	-	14,447

Figure 1

Surface Water Gaging Station Locations



- ▲ Gaging stations
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the othophotographs. 1/95
Surface water data from ER/Surface Water Group.
Updated April 1998.

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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/gis2/projects/fy98/98-0167/gaging-stations.aml